

Hyperbaric oxygen therapy

Concept's and myths

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Hyperbaric Oxygen Therapy

Introduction:

Hyperbaric oxygen therapy is defined as administration of 100% oxygen to a patient placed inside a chamber pressurised to greater than 1 atmosphere at sea level ¹. Local application of oxygen under high pressure without completely enclosing the patient is not considered to be hyperbaric oxygen therapy.

History:

Hyperbaric oxygen therapy is not a new concept. This concept historically can be traced back to 1600. The first hyperbaric chamber was constructed by British clergyman Henshaw ². He called the chamber *domicilium*. This chamber was pressurized and depressurized using bellows. In 1670 Robert Boyle observed that the eye of a snake could express gas bubble through the cornea. On observing this phenomenon he concluded that tissues undergoing rapid decompression causes expression of bubbles of previously dissolved gases. This prompted him to formulate the famous Boyles law, which states “*At constant temperature the volume and pressure of gas are inversely proportional.*”

Henshaw used his *domicilium* to facilitate digestion, to facilitate breathing, prevention of respiratory infections. This chamber provided only atmospheric air under high pressure as oxygen was not discovered till 1773 by Carl Wilhem Sheeley. The term oxygen was coined by Antoine Lavoiser only in 1777. ⁴French surgeon Fontaine was the first to build a pressurised mobile operating room in 1879 ³. He used Nitrous oxide as anaesthetic agent and believed hyperbaric oxygen chambers helped in better patient anesthesia.

Orwill Cunningham Professor of anesthesia (1928) ran a Hyperbaric oxygen hospital in Lawrence Kansas. He christened it as “Steel Ball Hospital”. This so called hyperbaric oxygen hospital was six stories high and 64 feet in diameter. This hospital could achieve pressure levels of 3 atmospheres ³. Cunningham claimed excellent results and he used this chamber to treat patients with spanish influenza ⁴ which was rampant during the first world war in United states. Two years later this hospital was closed down and scrapped for lack of scientific evidence.

Military found a unique use for hyperbaric oxygen chambers. Paul Bert demonstrated excess oxygen saturation caused grand mal seizures in humans. Navy used this chamber to quantify different exposure times to oxygen at varying depths that could lead to seizures in humans.

From 1930 onwards oxygen supplementation was used to manage acute decompression sickness. Oxygen when respired at very high pressures manages to displace nitrogen accumulated from the tissue. Use of hyperbaric oxygen considerably helps to reduce the time taken to treat decompression sickness. In 1935, Behnke showed nitrogen to be the common cause of narcosis in humans during decompression sickness. Behnke and Shaw successfully used hyperbaric oxygen to treat decompression sickness.

Indications of Hyperbaric oxygen therapy:

1. Arterial air or gas embolism
2. Acute blood loss anaemia
3. Carbon monoxide poisoning, cyanide poisoning, and smoke inhalation
4. Compromised skin grafts and flaps
5. Crush injury
6. Decompression sickness
7. To facilitate enhanced wound healing
8. Gas gangrene
9. Necrotising soft tissue infections
10. Radiation necrosis: Osteoradionecrosis, soft tissue radionecrosis, caries in radiated bones
11. Refractory osteomyelitis
12. Refractory mycosis
13. Thermal burns

Mechanism of action:

1. Hyperoxygenation – is achieved by first completely saturating the hemoglobin and then by increasing the amount of oxygen dissolved in the plasma. This increases the distance of oxygen diffuses away from the capillaries. This is three times higher than under normal conditions.
2. Vasoconstriction – Vasoconstriction caused by hyperbaric oxygen therapy does not reduce oxygenation, on the contrary it has a beneficial effect of reducing edema in skin grafts and flaps.
3. Antimicrobial activity – Hyperbaric oxygen therapy is bactericidal to obligate anaerobes. It also increases the ability of polymorphs to kill bacteria. It is also known to inhibit and inactivate the toxins released by clostridium welchi, thereby preventing gas gangrene.
4. Pressure effects – Hyperbaric oxygen is used to reduce the size of gas bubble. Because of this feature it is the treatment of choice in decompression sickness.
5. Neovascularisation
6. Fibroblastic proliferation
7. Improved functioning of osteoblasts and osteoclasts
8. Increased red cell deformability

Gamow bag⁵:

In 1990 Gamow devised a portable hyperbaric chamber which could generate pressures less than 1.5 Atmospheres. This bag is still being used by high altitude climbers to combat low air pressures at high altitudes.

Complications of Hyperbaric oxygen therapy:

1. Middle ear barotrauma – This can occur if the patient is unable to equalise the middle ear pressure. This complication can be best avoided by the use of systemic and topical nasal decongestants before

proceeding with hyperbaric oxygen therapy. If this condition occurs then myringotomy should be resorted to without hesitation.

2. Myopia – This is temporary and reverses back to normal after cessation of treatment.
3. Pneumothorax – can occur if decompression occur too rapidly or if the patient holds the breath during decompression.
4. Oxygen induced seizures – This complication is very rare. These patients should be given vitamin E before treatment to protect against superoxide radicals. Oxygen induced seizures can be stopped by allowing the patient to breath normal air. Oxygen induced seizures are not known to cause permanent neurological sequelae.

How to administer hyperbaric oxygen?

Hyperbaric oxygen is administered by placing the patient inside oxygen chambers. Two types of chambers are commonly used for hyperbaric oxygen therapy. 1. Monoplace and 2. Multiplace chambers. In both these chambers facilities are provided for monitoring the various vital body parameters like heart rate, blood pressure and blood oxygen levels etc. Facilities are provided for intravenous administration of drugs and fluids.

Monoplace chamber: Here 100% pressurised oxygen is utilized. Patient alone is placed in this type of chamber. There is no space for attendants. The patient is placed alone inside this chamber. This chamber is hence not useful in critically ill patients.

Multiplace chamber: These chambers are pressurised with air. Patients inside this chamber are administered 100% oxygen via a face mask or hood. These chambers allow one or more attendants inside them. This feature is advantageous in treating seriously ill patients.

Regardless of the type of chamber used the following factors must be considered:

1. The amount of pressure used.
2. Duration of the treatment.
3. How often the treatment is repeated.

To avoid oxygen toxicity the treatment duration should not exceed 120 minutes. The safe range being 90 – 120 minutes. The pressure used is about 2 atmospheres. When a patient's condition require multiple hyperbaric oxygen treatments per day, a minimum duration of 6 hours between them is a must.

Indications:

1. Radiation induced soft tissue necrosis: Hyperbaric oxygen therapy promotes neovascularisation. Hypoxia is corrected and wound heals faster.
2. Osteoradionecrosis: Hyperoxygenation and neovascularisation helps in treating this difficult condition. Hyperbaric oxygen treatment is an effective adjuvant to antibiotics in managing this condition.
3. Prevention of mandibular osteoradionecrosis
4. In treating necrotising soft tissue infections
5. In management of malignant otitis externa
6. Can be used in management of fungal infections of head and neck. This has a proven value as an

adjunct to the regular antifungal agents.

7. Management of acute blood loss anaemia

8. Can be used to salvage compromised skin grafts and flaps

9. Can be used as an adjunct in the management of patients with burns

10. Can be used to manage air or gas embolism

Contraindications for hyperbaric oxygen therapy:

Absolute contraindications:

1. Pneumothorax
2. Pulmonary damage

Relative contraindications:

1. Pulmonary bulla
2. Seizure disorder
3. Patients on high dose of steroids
4. Chronic obstructive pulmonary disorders
5. Recent myocardial infarction
6. Patients with claustrophobia



Fig. 1: Image of Hyperbaric chamber

Image of Hyperbaric oxygen chamber

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References

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